Mathematics Curriculum for Students in Rural Areas

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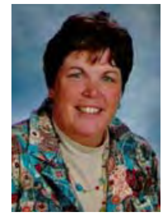
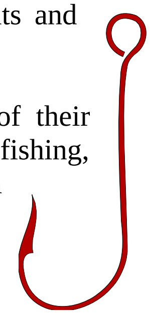


Mathematics educators argue that a strong mathematical education is necessary for *all* students because economic, social, and political opportunities depend upon it (National Council of Teachers of Mathematics [NCTM], 2000; Moses & Cobb, 2001). To develop mathematical powers, students must experience a high quality mathematics curriculum throughout their years in school. As a result, curriculum standards (e.g., NCTM, 2000) and curriculum materials developed with this goal in mind, are chosen by mathematics teachers keeping the context of their school and students in mind. In this paper, we consider the mathematics curriculum for students in rural areas. We begin by outlining characteristics of mathematics education specific to students in rural areas. Then we discuss a framework for designing mathematics curricula consisting of *rigor* and *relevance*. The framework is drawn from the literature on school reform (e.g., Daggett, 1995; Turner, 2005). A unit developed by the second author for students in her middle school mathematics class illustrates the framework.

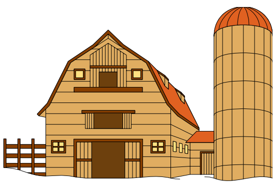
Mathematics Education in Rural Areas

Students in rural areas comprise a sizeable population in our country and they attend a significant number of schools. Beeson and Strange (2003) note that more than 30% of public school students in the U.S. attend schools in small towns or rural areas. Although rural areas in the U.S. are quite varied and the students represent diverse communities, their collective experience attending rural schools is likely to be different from the experiences of students attending schools in nonrural areas. For example, rural schools are typically smaller in size (Beeson & Strange, 2003) than non-rural schools, and are less likely to have advanced course offerings (Greenberg & Teixeira, 1998). Students in small rural schools usually have significant contact with their teachers both in and out of school (Nachtigal, 1992). All middle school and high school courses offered in a particular discipline may be taught by one or two teachers. Indeed, students may take all of their mathematics classes with the same teacher. As a result students and teachers get to know each other academically and personally.



Life in rural communities influences students' perception of the usefulness or importance of their mathematics education. The dominant occupations in rural areas are often connected to farming, fishing, forestry, ranching, or mining (Hobbs, 1992). The mathematics required or used when working in these occupations differs from that in occupations found in nonrural areas. As students contemplate their future in the adult world, they may look to the mathematical requirements of locally available employment opportunities as they consider the value of their mathematics education in school (Anderson, 2007; Chazan, 2000). Students' decisions regarding post-secondary education may be related not only to mathematics and other academic requirements but also to their willingness to move away from their home. Rural students often live farther from colleges or universities than their nonrural counterparts (Gibbs, 1998). As a result, the perceived importance of mathematics for continuing education beyond high school may be diminished if students do not wish to leave home for additional education or work. Ties to "home" can be more important than employment or educational opportunities when rural students decide on their residence (Hektner, 1995). It should be noted that the characteristics of the rural context do not suggest students in rural schools necessarily are at a mathematical achievement disadvantage when compared to students in non-rural schools (Fan & Chen, 1999; Greenberg & Teixeira, 1998; Lee & McIntire, 2000). In fact, Ballou and Podgursky (1998) suggest "rural schools offer a learning environment equal to or better than that available in urban area" (p. 12).

Like teachers elsewhere, mathematics teachers in rural schools face many challenges such as limited budgets, assessment mandates, difficult community economic conditions, and, at times, varied parental support and reluctant students. While most of these challenges are not within the direct control of the teacher, the day's lesson usually is planned and executed within the professional judgment of the teacher. Teachers in small rural schools may have significantly more independence planning lessons than teachers in other schools since they do not have to coordinate with others in a larger department.



In the following section we describe two components of a framework for choosing, designing, or adapting mathematics curriculum for students in rural schools. The curriculum unit used to illustrate the framework was developed for middle school students in a predominantly white, rural Midwestern community. Nearly 9,000 people live in the community and approximately 175 students are enrolled in each school grade, approximately half qualifying for free or reduced lunch. Farming is a dominant local industry along with a waning petroleum industry.

Framework: Rigor and Relevance

Rigor and relevance are the components of the curriculum framework. First, we suggest a *rigorous* mathematics curriculum expects students to engage in higher-level thinking and complex mathematical problem solving. Rigor includes allowing students the opportunity to be involved in genuine mathematical problem solving, designing and carrying out a plan, investigating possible solutions to challenging problems, and explaining solutions. Second, a *relevant* mathematics curriculum is one that connects mathematics to the life experiences of students, their present interests, and their occupational or educational futures (Turner, 2005). Students' prior experiences, interests, and aspirations vary and change so the mathematics curriculum must reflect the students in the classroom. Mathematical knowledge is relevant when it is created and used in the process of solving problems meaningful to students. In order to establish a curriculum that is both rigorous and relevant, teachers must require students to adapt what is learned within the classroom and relate it to settings outside the classroom.

Rigor and relevance are evident in the lesson described here. The second author was inspired to create the unit around flight after reading a newspaper article describing a program that offered children the opportunity to take a flight in a single engine airplane to increase their knowledge of and excitement for aviation and related careers. Keeping the 8th grade pre-algebra curriculum content in mind, she decided that flight would be a good avenue for investigating relationships among distance, rate, and time. Teaching these concepts within the context of flying promised to be both exciting and interesting for both students and teacher.

Rigor

Developing a more challenging and rigorous curriculum is a frequently prescribed recommendation for improving mathematics education in rural schools (Howley, Howley, & Huber, 2005). Conventional wisdom suggests this is necessary so rural students can have access to employment and educational opportunities after high school. As indicated earlier, a rigorous mathematics curriculum is centered on student problem solving. "Problem solving means engaging in a task for which the solution method is not known in advance" (NCTM 2000, p. 52).

There are many types of tasks that students are asked to engage in during mathematics classes. Not all of these are rigorous, and many do not expect students to cognitively engage in mathematical problem solving. In fact, in many classrooms, the teacher may take the responsibility for developing solutions and leave students with little opportunity to provide input to the problem solving process (Nachtigal, 1992; Stigler & Hiebert, 1999). In these cases, the demands on students' thinking are minimal. Smith and Stein (1998) have classified tasks by the cognitive demands placed on the students. They refer to memorization tasks and tasks where students perform procedures without connections to concepts or meaning as having lower-level cognitive demands. On the other hand, tasks with higher-levels of cognitive demands are those where students perform procedures with connections to concepts and meanings and where they are engaged in "doing mathematics." Students are "doing mathematics" when they are developing solutions to unfamiliar problems, applying their previous knowledge to new situations, reflecting on their thinking and strategies, and exploring mathematical relationships. A rigorous mathematics curriculum is designed around tasks with higher-level cognitive demands. That is, the curriculum reflects the mathematical processes: problem solving, reasoning and justifying, representing ideas, making connections, and communicating mathematically (NCTM, 2000).

Investigating Speed

The pre-algebra unit on speed was centered on a task with higher-level cognitive demands. The students were to determine the speed (rate) of a traveling Lego Mindstorms robot while a leaf blower was used to simulate the wind. Previously students had done some work with the distance-rate-time relationship and solving equations. Students drew on their knowledge of wind as they solved the problem of figuring out the robot's speed.

In groups of three, the class tackled the task of figuring out a way to determine the robot's speed. They had not solved this particular problem before and were not expected to follow a worked example done by the teacher. Rather, the teacher asked them to devise a step-by-step procedure for the experiment. After allowing students time to record their procedures, they had a class discussion on the best method for finding the speed of the robot and ran an experiment to determine the rate by measuring the distance traveled by the robot in a five second interval.

At this point in the lesson, the teacher introduced the leaf blower as a wind source. The class discussed times in their own lives when students may have experienced the effects of wind. Some students mentioned running in track, others riding a bicycle, and still others talked about the effects of wind while playing baseball or football. From this conversation it was clear that the students were relating their experience when they ran into the wind (headwind) and ran with the wind (tail wind) to the effect that the leaf blower would have on the robot's speed. The students proceeded to find the speed of the robot as it traveled with a tailwind or a headwind. The teacher asked the students to once again write a procedure for testing the effect of the wind on the robot's movement and asked them to make a prediction about what might happen. When they had finished recording their procedures the class had another discussion to settle on the best procedure for the experiment before running the experiment again. The effect was exactly as expected: the robot stopped short of its original finish line. The class determined the speed of the wind by developing the equation: Distance = time × (speed of robot without wind – speed of the wind). The students knew the wind had to slow down the robot because it covered less distance in the same amount of time.

A third part of the task was for students to create an experiment to determine the tailwind. They repeated the process as before; but this time the teacher asked them to predict what would happen and write an equation that they thought they might use. In doing this, the students began to realize the missing variable was distance, because they knew the speed of the robot, the wind speed (from the second experiment), and the time that it would travel. The students solved the equations to make predictions on how far the robot would travel with a tailwind. The class discussed their predictions and performed the experiment. It was clear that students realized that a headwind slowed the robot's speed and a tailwind increased it.

Throughout this lesson, students were exploring the relationship between distance, speed (rate), and time, and the effect of wind on of the robot. They had to consider and reflect on their plan for the experiments as they wrote about their ideas and then discussed them as a class. With the teacher's guidance, they considered the effects of wind through their own experiences and made connections to the results with the robot. The equations that were developed were not mindlessly followed; instead they were developed in relation to the experience of the experiments. For example, subtracting the speed of the wind from the speed of the robot was meaningful because their experience in the wind outdoors and their observations of the robot indicated the speed of the robot decreased when it faced a headwind.

Relevance

Relevance in the mathematics curriculum depends on tasks that connect mathematics to the real life experiences of students, their present interests, and their potential futures. Contexts of tasks within a mathematics curriculum that are relevant for one group of students may not be relevant for another. Rural students may find that the tasks presented in contemporary mathematics textbooks do not reflect their experiences of life in rural areas (Schultz, 2002). Contexts for tasks in a mathematics curriculum relevant to rural students should be related to the experiences of the students who makeup the class.

One way to accomplish increased relevance in the curriculum is to view mathematics as a human activity, "the process of modeling reality with the use of mathematical tools" (Fosnot & Dolk, 2002, p. 9). Problem solving situations can arise from the in-school and out-of-school experiences of the students. In this way, mathematics is used as a way to explain phenomena in the students' lives, to explore relationships, and to convince others of decisions made.

Extending the Unit

During the unit on speed, the task engaged in by the 8th grade students was connected to their own experiences of feeling the effects of wind through activities in their lives. The unit was then extended to connect speed to the broader experience of flight by providing students a shared experience of flight at the local airport. Prior to this field trip, a pilot came to the school to explain that an airplane must take off into the wind so that the speed is not accelerated to the point that the runway ends before the plane is off the ground. From their experience with the tailwind on the robot in the classroom, the students better understood that a tailwind could cause the plane's distance to exceed the runway's length before it left the ground.

As students have opportunities to see connections between mathematics and real world settings, they are motivated to think, wonder, and imagine how they could personally use mathematics in their own lives. Some students may continue their study of mathematics through high school because it is necessary for future occupational or educational opportunities. For others, however, an irrelevant curriculum can cause them to cease their study of mathematics (Anderson, 2007). A curriculum built around relevant contexts –

ones connected to the students' lives – will be meaningful and valuable independent of the value the learning holds for the future. When students make connections between their lives and what is taught in school, they have learned the value of mathematics.

The lessons on flight proved rigorous because students were involved in "doing mathematics," and relevant because of the connection to the first-hand experiences of wind and flight. It is unknown whether or not students in this class will fly again or investigate opportunities in the field of aviation. Yet, they have gained an understanding of how mathematics is relevant and connected to real life situations.

Conclusion

All students need access to a high quality mathematics curriculum. Teachers can use the framework described here as they adapt and develop a curriculum for the specific students in their classroom. The mathematics curriculum must be rigorous with students engaged in cognitively demanding tasks. The tasks in the curriculum must be relevant to the students – connected to their experience of "real life."

Development of such a mathematics curriculum is not without challenges. To create lessons that combine rigor and relevance, teachers need significant knowledge of mathematics, how students learn mathematics, and materials available for teaching mathematics. Teachers may be well advised to start small: First, find a topic of interest within the existing mathematics curriculum. Next, decide on tasks that are cognitively demanding to scaffold learning for the students. Then, consider the understanding of the concepts students possess and what they will need to develop and build. Failures will happen and revisions will be necessary. However, students and their communities will be well served by a strong mathematics curriculum.

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Quote

Aristotle maintained that women have fewer teeth than men; although he was twice married, it never occurred to him to verify this statement by examining his wives' mouths.

The Impact of Science on Society, 1952. Russell, Bertrand (1872-1970)
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